Amendments to the Specification:

Please replace the single paragraph in the **Cross-Reference to Related Applications** section with the following rewritten paragraph:

This patent document ~~application~~ is a divisional patent document ~~application~~ of U.S. Patent Application No._09/113,891, now abandoned, entitled "Method and Apparatus for Treating Flue Gas" and filed on July 10, 1998, which claims the benefit of the filing date of Provisional ~~of Provisional~~ U.S. Patent Application No. 60/052,816 entitled "Heat-Exchanger/Wet-Film Electrostatic Precipitator for Flue Gas Cleaning" and filed on July 10, 1997. Accordingly, this divisional patent document ~~application~~ claims the benefit of the filing date of Provisional U.S. Patent Application No. 60/052,816, and the entire disclosure of that provisional application is incorporated into this divisional patent document ~~application~~ by reference.

Please replace the paragraph beginning on page 2, line 2 with the following rewritten paragraph:

In known processes for electrostatic purification of dust- and pollutant-containing ~~pollutant-containing~~ exhaust gases, the latter are subjected to an electrostatic purification under dry conditions in a first processing stage and in a succeeding second processing stage are subjected to an electrostatic purification under wet conditions. One or more electric fields operating under dry conditions, and one or more electric fields operating under wet conditions are arranged in succession. The water is sprayed through nozzles into the wet field or fields and is drained as a slurry, which is concentrated in thickeners and is then injected by means of steam or compressed air into a drying tower, in which the

evaporated liquid humidifies the hot drying gas so that a back corona discharge in the fields operating under dry conditions is prevented. Acid components, such as SO_X, HF and HCl, are absorbed from the liquid which has been sprayed into the wet stage and, together with the dust which is still collected in the wet stage, enter a sump disposed in the wet stage. A disadvantage of that process resides in that the sludge formed in the sump of the wet stage contains a relatively large amount of pollutants in addition to the dust, and for this reason, the sludge can be processed only with difficulty. A further disadvantage of that process resides in that the evaporated liquid which has been injected into the drying tower will moisten the dust- and-pollutant-containing exhaust gas so that its dew point temperature will be increased. Because the gas temperature is decreased at the same time, the temperature in the electrostatic precipitator will decrease below the dew point temperature so that a corrosion caused by the acid components of the exhaust gas cannot be avoided.

Please replace the paragraph beginning on page 3, line 18 with the following rewritten paragraph:

U.S. Pat. No. 1,766,422 also describes the electrostatic purification of dust- and pollutant-containing exhaust gases in a process in which the exhaust gas laden with dust and pollutants is first subjected to electrostatic purification under dry conditions and subsequently to electrostatic purification under wet conditions. In that process, the collecting electrodes of the wet electrostatic purification stage are wetted with a treating liquid. The electrostatic precipitator is operated at such a high gas velocity, that the particles of the fine fraction will be collected in the dry electrostatic purification stage, and those of the coarse fraction will be collected in the wet electrostatic purification stage. In that process, the

sludge formed in the sump of the wet electrostatic purification stage will contain a relatively large amount of pollutants in addition to the dust. An additional disadvantage of that process resides in that the exhaust gas is passed through the electrostatic precipitator at a relatively high gas velocity to ensure ~~endure~~ that the coarse particles of the dust contained in the exhaust gas can be collected in the wet electrostatic purification stage. As a result, the residence time of the exhaust gas in the wet electrostatic purification stage is not sufficient to ensure that the pollutants contained in the exhaust gas will be removed to a sufficient degree.

Please replace the paragraph beginning on page 4, line 18 with the following rewritten paragraph:

U.S. Pat. No. 4,364,910, Willet et al., issued Dec. 21, 1982, discloses a similar system and process for flue gas processing, to remove both gaseous contaminants, such as sulfur dioxide, and particulate matter such as flyash. This process integrates spray scrubbing apparatus, and wet electrostatic precipitation apparatus, and provides for the advantageous extraction and utilization of heat present in the flue gas which is being processed. The integrated system and process utilize a spray scrubbing tower into which the flue gas in introduced and into which aqueous alkali slurry is introduced as spray for sulfur dioxide removal therein. The flue gas leaves the tower in a moisture-laden state, and enters a wet electrostatic precipitator which includes a heat exchanger, where flyash and entrained droplets in the flue gas are removed by electrostatic precipitation and that is removed from the flue gas. The cleaned flue gas exits from the precipitator and discharges into a stack. The wet electrostatic precipitator of the integrated system and process includes a portion

constructed as a cross- flow heat exchanger, with flue gas saturated with water vapor moving vertically upward inside tubes arranged in a staggered pattern, and ambient air being pulled horizontally across the outside of those tubes to cool the tube walls and thereby remove heat from the flue gas and cause condensation of water vapor on the inside wall surfaces. The condensate washes the electrostatically collected flyash particles down from the inside tube walls.

Please replace the paragraph beginning on page 4, line 22 with the following rewritten paragraph:

U.S. Pat. No. 4,776,391, Warner, issued Oct. 11, 1988 ~~19088~~, discloses a flue gas cleaning system, whereby an exhaust gas containing sulfur trioxide is passed through a first heat exchanger which cools the gas to a temperature which is above the sulfur trioxide dew point, so that condensation of sulfur trioxide does not occur in the first heat exchanger, but which is below a material-limit operating temperature of a second heat exchanger, which further cools the gas below the sulfur trioxide dew point, whereby the first heat exchanger is protected against corrosion and the second heat exchanger is protected against thermal damage.

Please replace the paragraph beginning on page 8, line 5 with the following rewritten paragraph:

U.S. Pat. No. 5,137,546, Steinbacher, et al., issued August 11, 1992, discloses a process and an apparatus for the electrostatic purification of dust- and pollutant-containing ~~pollutant-containing~~ exhaust gases in multiple-field precipitators. The exhaust gases are first subjected in a first stage to an electrostatic purification under dry conditions in

gas passages defined by plate-like collecting electrodes, and are subsequently passed in a second stage through one or more fields defined by liquid-wetted collecting electrodes, which define gas passages. The liquid which is supplied in the second stages at the top ends of the collecting electrodes is laterally discharged from the precipitator, and the substantially dry dust which is still collected in the second stage is fed to dust-receiving means.

Please replace the paragraph beginning on page 12, line 8 with the following rewritten paragraph:

Some of the advantages of the invention over the related art include (a) low gas-phase ~~gas-pHase~~ pressure drop; (b) low liquid-pumping cost; (c) high removal efficiency of sulfur oxides and nitric oxides; (d) high-efficiency removal of particles; (e) high-efficiency heat recovery; and (f) water recovery from flue gas with low water evaporation, thereby decreasing water usage.

Please replace the paragraph beginning on page 14, line 7 with the following rewritten paragraph:

The flue-gas treating device 10 shown in Fig. 1, in accordance with the principles of the invention, includes a first section 11 having a sensible-cooling heat exchanger (not numbered) ~~12~~ and a first electrostatic precipitator (not numbered) ~~14~~. The device 10 is ideally suited for treating a flue gas containing a dust or a pollutant. As used herein, the term "dust" refers to any solid particle within a flue gas, with one example being flyash. The term "pollutant", as used herein, includes acid gases, metals, metallic compounds, and chlorinated organic compounds. Examples of acid gases include sulfur-containing oxides (SO_X) and nitrogen-containing oxides (NO_X), as well as chlorine and

fluorine, in any particular state. For example, the chlorine or fluorine may be atomic, including ionic, and/or a part of a compound. Examples of a metal pollutant, in either pure or metallic-compound form, include mercury, selenium, arsenic, lead, chromium, cadmium, beryllium, nickel, and manganese. Examples of chlorinated organic compounds include dioxins and furans.

Please replace the paragraph beginning on page 14, line 21 with the following rewritten paragraph:

As mentioned briefly above, the first section 11 includes a sensible-cooling heat exchanger <u>(not numbered)</u> ~~12~~. As used herein, the term "sensible cooling" refers to a form of cooling which is accomplished without condensation of water which may be present in the flue gas, and without evaporation of water which may be present in the <u>flue gas</u> ~~flue-gas~~. In further detail, the term "sensible cooling" refers to cooling without changing the humidity mass ratio of the flue gas. The humidity mass ratio may be defined as the mass of water divided by the mass of dry flue gas.

Please replace the paragraph beginning on page 15, line 5 with the following rewritten paragraph:

As shown in Fig. 1, the sensible-cooling heat exchanger <u>(not numbered)</u> ~~12~~ and first electrostatic precipitator <u>(not numbered)</u> ~~14~~ are located within a first housing <u>(not numbered)</u> ~~16~~, with the housing <u>(not numbered)</u> ~~16~~ having a flue-gas inlet 18 and a flue-gas outlet 20. The heat exchanger <u>(not numbered)</u> ~~12~~ and precipitator <u>(not numbered)</u> ~~14~~ advantageously are of the plate variety; most advantageously, the heat exchanger <u>(not numbered)</u> ~~12~~ and precipitator <u>(not numbered)</u> ~~14~~ are one in the same, being either a heat

exchanger or a collection plate, modified as necessary, and operated to serve the dual functions of sensible cooling and dust collection. The resulting assembly is referred to herein as a heat exchanger/collection plate assembly 15. Upon reading this Detailed Description, those of ordinary skill in the art will readily understand that several heat exchanger and/or collection plate units may be fluidly connected to one another to form one or more assemblies 15, as needed, in order to provide a desired surface area sufficient for adequate sensible cooling and particulate collection. Moreover, the heat exchanger and/or collection plate units may be aligned within the housing 16 in any of a number of conventional design patterns. For example, as shown in Fig. 4, two rows of heat exchanger/collection plate assemblies 15 are arranged within the housing 16, on either side of a series of corona wires 17, thereby forming a central flue gas channel 19.

Please replace the paragraph beginning on page 16, line 7 with the following rewritten paragraph:

With regard to the sensible-cooling aspect of the invention, any suitable fluid may be used, with water being a convenient choice. In addition, any suitable pattern of fluid flow through a heat exchanger/collection plate assembly may be used. Advantageously, if an exchanger/collection plate assembly is oriented in a vertical alignment, the fluid flow is a counter-current flow, with the fluid entering the exchanger/collection plate assembly near ~~that~~ the rear of the housing, and circulating up and down through the exchanger/collection plate assembly toward the front of the housing. As noted above, while any suitable heat exchanger(s) and/or collection plate(s) may be used, the exchanger(s)/plate(s) should be grounded, and also should be hung from a support

structure within the housing 16, as shown, for example, in Figs. 2-5. In addition, the corona wires 17 may be suspended from a support structure; however, as will be understood by those of skill in the art, these corona wires 17 should be electrically isolated and insulated using a conventional insulation 21. If desired, as understood by those of skill in the art, the housing 16 may be provided with a solenoid-operated anvil which may be dropped down onto the heat exchanger/collection plate assembly or assemblies 15, thereby causing clumps of dust to fall to the bottom of the housing 16, where they may be removed by a conventional dust-collecting hopper or any other suitable device, as is understood in the art. The power to the first housing 16 beneficially is provided using a transformer rectifier which enables a different amount of current to be supplied to each heat exchanger/collection plate unit in an assembly 15, if more than one unit is combined to form a given assembly 15.

Please replace the paragraph beginning on page 17, line 6 with the following rewritten paragraph:

One purpose of the first section 11 is to simultaneously remove dust (mostly flyash) and recover heat sensibly, maintaining a dry condition in order to minimize or prevent the risk of corrosion in the section 11. The temperature of the first section 11 ~~is~~ advantageously is maintained from about 5°F to about 30°F above the dew point temperature. To prevent collection of sulfur trioxide and other acidic compounds on the exchanger/collection plate assembly 15, a small amount of calcium hydroxide or another alkaline material (e.g., ammonia gas), up to about 10% of the total acid molar amount of SO_X, may be injected upstream of the first section 11. Because the heat

exchanger/collection plate assembly 15 performs dust collection and heat recovery at the same time, significant savings in materials and pressure drop may be achieved.

Please replace the paragraph beginning on page 21, line 11 with the following rewritten paragraph:

In further detail, and with reference to Fig. 1, this particular flue-gas treating device 10 has a pollutant-laden liquid line 36 connected to the second housing 28. This line includes a first chemical-separation member 38, a heat exchanger 56, and a second chemical-separation member 40, with each chemical-separation member 38,40 advantageously being a settling tank. In one particular form of the invention, the first chemical-separation member 38 may be used to remove sulfur-containing oxides, metals, and/or metal-containing compounds from the pollutant-laden liquid in the pollutant-laden liquid line 36. In addition, the second chemical-separation member 40 may be used to collect pollutants such as chlorides and/or nitrogen-containing oxides. A spent-liquid return line 42 is connected to the pollutant-laden liquid line 36, and advantageously may be used to return liquid to the collecting-liquid delivery element 22 in the second housing 28. <u>If desired, the line 42 may include a heat exchanger/water pump 58.</u> Although not required, the liquid passing through the spent-liquid return line 42 advantageously will have had one or more pollutants removed during its pass through the pollutant-laden liquid line 36. This aspect of the invention is particularly beneficial in that it enables liquid to be conserved as the particular flue gas is being treated.

Please replace the paragraph beginning on page 29, line 5 with the following rewritten paragraph:

In a typical multiple-field flue-gas treatment system in accordance with the principles of the invention, such as the system shown in Fig. 1, the exhaust gas may be produced by a furnace or boiler at a rate of about 400,000 standard cubic meters (sm^3) per hour. The exhaust gas generally will have a temperature of from about 275°F to about 325°F and a dew point temperature of from about 105°F to about 120°F. In such a system, the treatment usually takes from about 1 s to about 25 s in the first section, and from about 1 s to about 25 s in the second section. The collecting surface area of the collection plates of the second section typically amounts to from about 10% to about 60% of the total collecting surface area of the system. The throughput of the liquid with which the collection plates are wetted generally amounts to from about 10,000 m^3/h to about 100,000 m^3/h. A field strength in the range of from about 5 to about 60 kV/cm may be used, and the measured residual content of dust-like materials usually amounts to from about 1×10^2 to about 1×10^5 mg/cm^3 after the treatment in the first section, and to from about 1 to about 1×10^4 mg/cm^3 after the treatment in the second section. The temperature drop adjacent the wetted collection plates amounts generally to from about 1 to about 100°F. Each of the first and second sections of such a multiple-field system contains at least one electrostatic field. If the exhaust gas rate amounts to about 400,000 m^3/h, the field strength should be from about 5 to 60 kV/cm, and the total collecting surface area of the system should be in the range of from about 400 to about 700 m^2.

Please replace the paragraph beginning on page 32, line 20 with the following rewritten paragraph:

Exhaust gas is produced by a flue gas generator at a rate of about 400,000 standard cubic meters (sm^3) per hour. The exhaust gas has a temperature of about 275°F and a dust content of 5×10^6 g/sm^3. The treatment in the multiple-field precipitator flue-gas treatment system takes about 12 s in the first section and about 10 s in the second section. The collecting surface area of the collecting plates of the second section amounts to about 40% of the total collecting surface area of the treatment system. The throughput of the liquid with which the collecting plates are wetted amounts to about 67,000 m^3/h. A field strength in the range of from about 17 to about 20 kV/cm is used, and the measured residual content of dust-like materials amounts to about 1×10^2 mg/cm^3 after the treatment in the second stage. The limits for vaporous and gaseous inorganic substances, particularly the limit of 100 $\underline{mg/cm^3}$ ~~mg/sm³~~ for SO_2, are not exceeded in the experiment. The temperature drop adjacent the wetted collecting plates amounts to about 20°F. As a result, the gas temperature is decreased to about 183°F and the dew-point temperature is raised to about 47°F.

Please replace the **Abstract of the Disclosure** with the following rewritten abstract:

A multiple-field precipitator, flue-gas treating device, in accordance with the principles of the invention, includes a first section having a dual-function, sensible-cooling heat exchanger/electrostatic precipitator, a second section having a wet electrostatic precipitator, and a middle section fluidly connecting the first and second sections. In the first section, the exchanger/precipitator sensibly cools the flue gas and collects most of the dust from the flue gas. In the middle section, the dust-reduced flue gas is combined with an alkaline material,

thereby forming reaction products. These reaction products and several other pollutants are captured by the wet electrostatic precipitator, in the form of a pollutant-laden liquid. The pollutant-laden liquid is directed to a series of heat exchangers and settling tanks, where various pollutants such as SO_X, metals, NO_X, and chlorides are removed in different stages. In addition, ammonia is liberated from the pollutant-laden liquid, and circulated back to the middle section, where it is combined with additional dust-reduced flue gas to form additional reaction products for subsequent capture in the wet electrostatic precipitator.